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Susanne Jakob
Dipl.-Ing. Helge Drumm

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B. Erixson and Prof. J. Seitz

Service Discovery Modelling for Intelligent Building Network

Multimedia Communications

Abstract

The research and development of smart home technologies and its application grow rapidly. Discussing about the smart home and its technologies takes us to discuss also about the residential gateway, which will be depicted in this paper as the central point for the intelligent building as the access gateway of every applied home devices, technologies and protocols. This residential gateway will act as entrances for the personal area networks to connect other personal area networks or local area networks through the interconnecting infrastructures. And then by the home networks there is a crucial question, how does a device know the services or resources, which is available on his environment.
The objective of this paper is to develop a service discovery mechanism for the network so it can provide service information such as service availability for the requesting device.

Keywords: UPnP, OSGi, access gateway

1. Introduction

The research and development of smart home technologies and its application grow rapidly. Discussing about the smart home and its technologies takes us to discuss also about the residential gateway, which will be depicted in this paper as the central point for the intelligent building as the access gateway of every applied home devices, technologies and protocols. This residential gateway will act as entrances for the personal area networks to connect other personal area networks or local area networks through the interconnecting infrastructures.

The objective of this paper is to develop a service discovery mechanism for the network so it can provide service information such as service availability for the requesting device. There are some problems or challenges of this paper that the service discovery must be operated over the different interfaces like Wide Area Networks and Local Area Networks and the other is that the service discovery must be operated over the different technologies like Universal Plug and Play or JINI.

In order to achieve this concept, it is needed to design the service scenario that supports this service discovery concept. And then the designed scenario must specified, what kind of home network technologies can support this concept. After that we can try to reach it through the implementation of the specified system. This paper is structured as follows. In the next session, the service scenario design is introduced. After it will be described the design and analysis of the supporting technology of this concept, and then it will be followed with the part of the system design description.

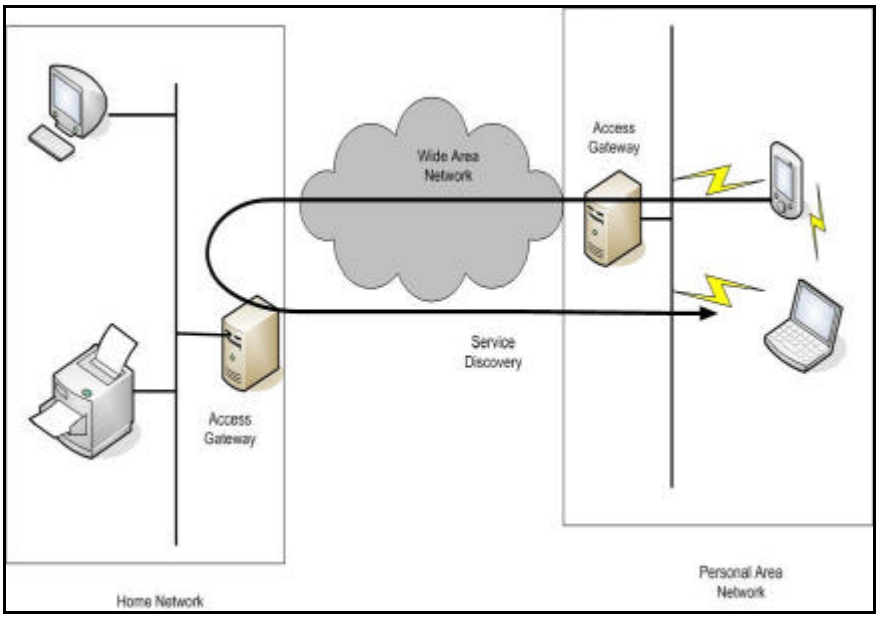

Fig. 1 Service Discovery for the home network

And then the partial simulation implementation of service discovery on the residential gateway will be described and then in the final chapter will be closed with the conclusion.

2. Service Scenario Design

The networks are today intended becoming an integrated service-centric network. This tendency comes, while the services becoming smarter more and more. As an example, services have the ability to learn from the previous events, being aware of the other resources and services, and advertise capabilities to others. These features make acceleration for the “old” separated networks to combine into a more flexible service network.

One of the interesting challenges of the concept of service device and discovery for the home networks is that how to make a heterogeneous networks interoperate to each other. Because of that we make first a scenario description.

Someone wants to make some pictures by using his mobile phone, and he want to share his photos to his friends. He finds a public access gateway around himself and then the process of this story continues as following:

0) Device discovery through Bluetooth
   His mobile phone and the public access gateway find each other wirelessly
1) Requesting Service
   The mobile phone sends the request to the public access gateway
2) Service Discovery
   The public access gateway checks the service availability through the service inventory or external network, and then it sends the result back to his mobile phone.
3) Service Invocation
   If he gets the acknowledgment, that the printer is ready, he will proceed to transfer the photos to the public access gateway. And then the photos will be printed out from his printer in his home.

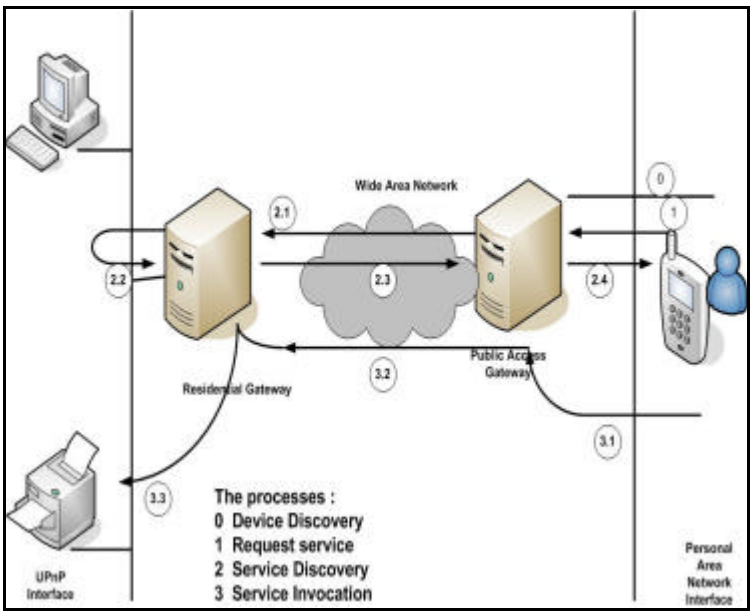

Fig.2 The scenario of service discovery for home network

2.1 The chosen technologies for designed scenario

There are some technologies that could be taken as the consideration.

a. Bluetooth or WLAN for the personal area network.Universal Plug and Play (UPnP) that applied in Local Area Network.
b. UpnP is anticipated to be the solution for the home network because it realizes zero-configuration and interoperability within a wide range of devices no matter what their physical medium (IEEE 1394, Ethernet, USB, Bluetooth, WLAN) are. Once a new UpnP- enabled device is on-line, it can make itself be noticed and controlled by a special kind of UpnP device, called UpnP Control Point, without any further configuration such as driver installation.
c. Open Service Gateway Initiative (OSGi) that applied in residential gateway.
d. OSGi is chosen to act as the gateway's platform. OSGi provides a strong environment for multiple Java-based components to work on a single Java Virtual Machine (JVM), and its compatibility with UpnP. But in this paper we don't discuss about its other attractive features such as remote configuration, because it is out of the investigation for this paper.
e. Wide Area Network
   It is used as the infrastructure for interconnection between residential gateway and the public access gateway.

2.2 Supporting technology analysis

As a review, we take a little time to describe why we selected these technologies as the communication technologies for smart home networks and personal area networks.

2.2.1 UpnP

UpnP is an open standard and it uses also existing Internet and Web Protocols to enable devices such like Personal Computers, intelligent appliances, and wireless devices to be plugged into a network and know each other without manual configuration. When an UpnP device is plugged into the network, it will configure itself, acquire an IP address, and announce its presence; a special UpnP device called the control point will notice the newly

added device, acquire its capabilities, what services the device provides, and finally play the device. Every process is automatic.

Shortly, the main reason why UpnP is chosen as the part component of this scenario, because its reliability and characteristics such as:

- Physical layer independent
  UpnP can run on a great wide range of devices as long as their underlying mediums have IP stack, regardless of the physical network they are attached to. The physical medium could be: IEEE 1394, Ethernet, USB, Bluetooth, WLAN (802.11).
- Original-standard- based
  UpnP is built on existing Internet and Web Protocols / standards such as IP, TCP, UDP, HTTP, SOAP and XML Using these well-known protocols allows UpnP to benefit from a huge pool of experience and knowledge, simplify the design of UpnP devices, and endow UpnP devices with inherent interoperability.
- Zero configuration.
- Once a new UpnP device is plugged into the network, it can work right now without any configuration. It is so because standard protocols, instead of any device drivers,are used to implement UpnP devices.
- It has a flexible service discovery mechanism
- And very suitable to build the home network

2.2.2 OSGi (Open Service Gateway Initiative)

OSGi (Open Service Gateway Initiative) service platform, contributed by OSGi Alliance, specifies a standard environment which allows multiple, Java-based components, called *bundles*, to run in a single Java Virtual Machine (JVM) securely.
And one of the reliability and the main reason, why OSGi is selected as the component od this design, because the using of UpnP and OSGi is a decent combination, where:

- UpnP control point running on OSGi platform can discover non OSGi-resident UpnP devices on the network.
- UpnP devices running on OSGi platform can be available to non OSGi-resident UpnP control points on the network.

Therefore, the OSGi UpnP control point could discover OSGi-resident UpnP devices as well as non OSGi-resident UpnP devices on the network, while the situation is similar to the non OSGi-resident control point.

2.2.3 UPnP Base Driver

UPnP base driver is a vital component in UPnP and OSGi combination mechanism. It is actually an OSGi bundle that implements the UPnP protocols and handles the interaction with bundles that use the UPnP devices. There are two critical responsibilities of UPnP base driver bundle:
- Import UPnP devices from the network to the OSGi framework
The UPnP base driver has ability to detect UPnP devices on the local network, instance them as OSGi services with the uniformed interface *UPnPDevice.* And then and finally register these OSGi UPnPDevice services to the service registry of the OSGi framework. These UPnP devices, imported from the network to the OSGi service registry, are called *Imported Devices*.

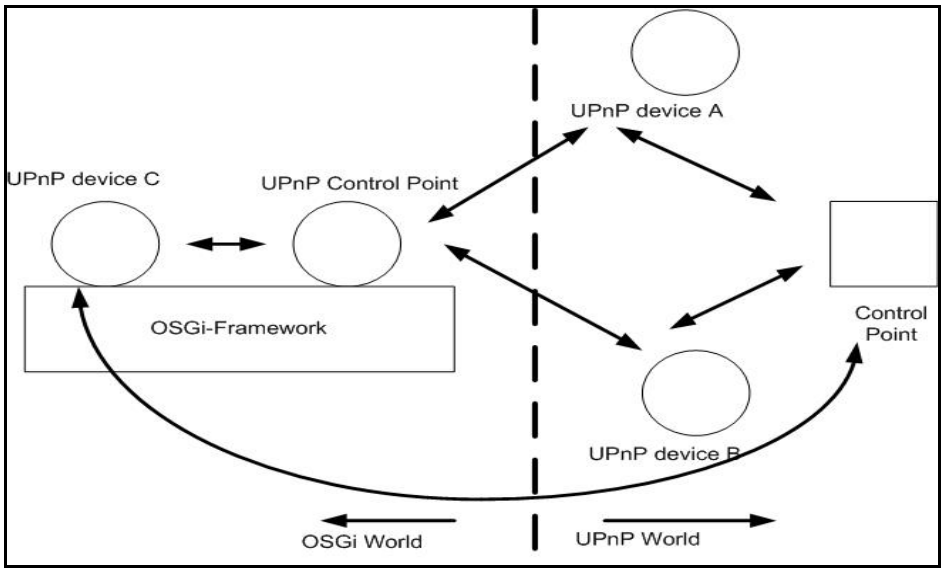

Fig.3 Interaction model of UPnP and OSGi

- Export UPnP device from the OSGi framework to the network.
  The UPnP base driver has an ability to make UPnP devices, which are already registered in the service registry as OSGi UPnPDevice services available to the other networks. These UPnP devices, exported from the OSGi service registry to the network, are called *Exported Devices*.

3. System design and description

In this chapter we describe the system design of service discovery of the residential gateway that implement UPnP and OSGi on the residential gateway.

3.1 General design

As the general design that depicted on figure 5, where:

1. The personal network (mobile device) provides user interface for user, and interacts with the public access gateway.
2. Personal network (public access gateway), playing as intermediary between residential gateway and the mobile device.
3. The residential gateway interacts with personal resources as well as the public access gateway.

As we told on the first session, now we describe the model and simulation of the service discovery on the residential gateway.

The OSGi framework is built on the residential gateway, which its functionalitiy is like the normal computer. This OSGi specification is contributed by the OSGi organization, and two of them are the open source implementation. They are OSCAR and Knopflerfish. We can not judge, which is the better one of them, because both of OSCAR and Knopflerfish has its own advantages. But in this paper we don't talk about their advantages and weakness.

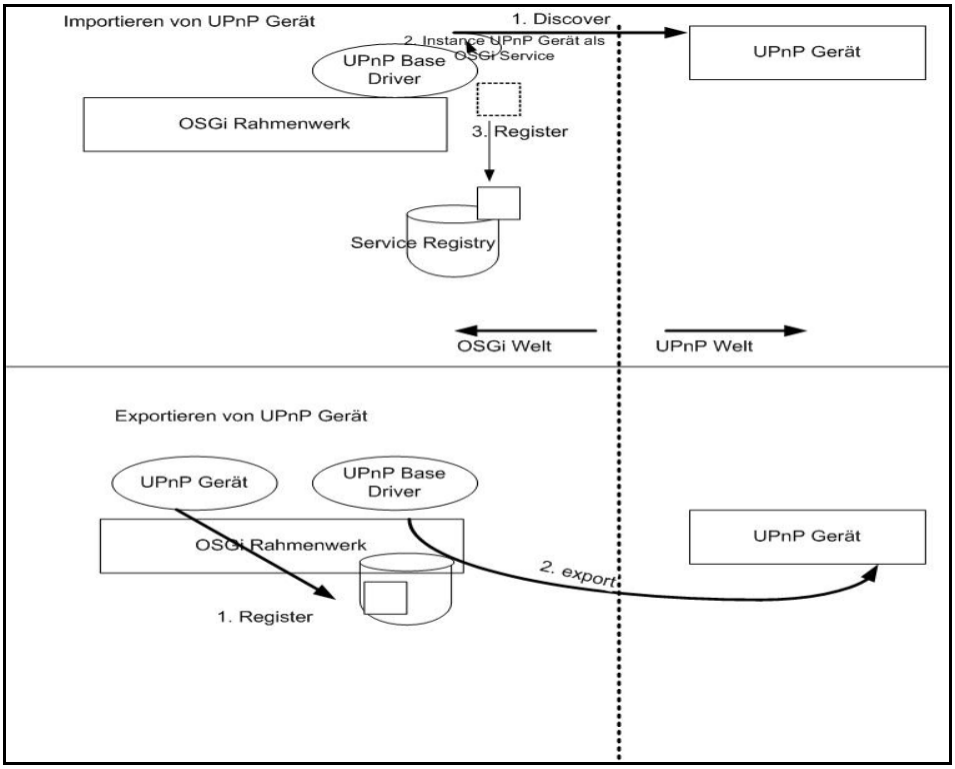

Fig. 4 The functionalities of UPnP Base driver bundle

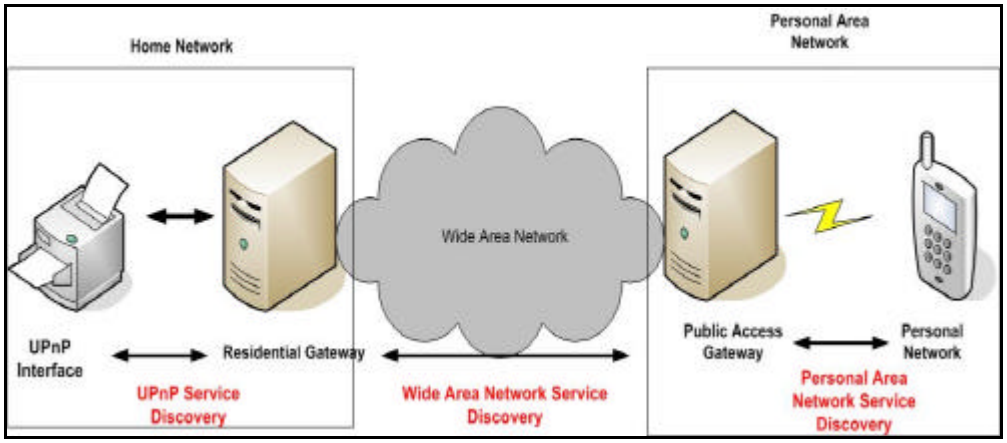

Fig. 5 rough module of the general design of service discovery

3.2 Mandatory bundles specific for this implementation

When starting OSCAR OSGi framework, a set of default bundles will run to support what specified in OSGi standard. However, they are not enough for specific applications which require additional bundles. For the residential gateway application, at the moment two more bundles are expected, UPnP-API bundle and UPnP Base Driver bundle.

- *UPnP-API* bundle is a kind of “library” bundle, that contributed by OSGi organization. It combines OSGi and UPnP decently. It makes UPnP working mechanism run on OSGi world. That is, when an UPnP device and a Control Point are installed on OSGi framework, they interact as in the pure UPnP network without noticing OSGi as long as they are created by use of APIs contained in the UPnP-API bundle.

- *UPnP Base Driver* bundle can be considered as a bridge between OSGi world and UPnP world. OSGi specification simply gives two functions of UPnP Base Driver must provide: importing UPnP devices from network out of OSGi framework, and exporting UPnP devices on OSGi framework to network.

3.3 Integrated Development Environment

Among the three popular Java IDEs, JBuilder, NetBean, and Eclipse, Eclipse becomes the final decision because it is open source and consequently is supported by a huge knowledge and experience, and most important its functionality is greatly extended by a rich set of plug-ins. As example, Together plug-in can be able to generate codes from UML diagram such as Class Diagram, and more amazing feature is that it works in the reverse direction, saying, it could create class diagram or even sequence diagram from codes.

3.4 Making Class Diagram

There are six steps involved in the UPnP networking:

1. Addressing: UPnP control points and devices get IP addresses.
2. Discovery: the control point searches for interesting devices or the device advertises its services.
3. Description: the control point learns device capabilities.
4. Control: the control point invokes services on device.
5. Eventing: the control point listens to device updates.
6. Presentation: the control point controls device and/or views device status via HTML user interface.

By the making of this simulation, the class making features has abilities such as:
a. discovering device coming or leaving.
b. controlling device by invoking service's actions.
c. subscribing to event.

To make the structure become easier. In this work, there are just two things are investigated.
The control point that is, except original classes *UPnPSubscriber* and *ControlPointMain* not involving and minor modifications, all other codes keep unchanged. The corresponding class diagram is depicted in figure 5. This class diagram is suitable with the OSCAR OSGi, where, some of the class is already existed in OSCAR OSGi frame work/ has fulfilled the need of this class diagram.

In this model, the class *Activator* will act as the control with the OSCAR OSGi framework.Control (manipulates the whole application), is acted by class *Activator* and Knopflerfish OSGi framework. There are still some classes such as View (displays Model), holds *ControlPoint* class and its subclasses *TreeViewer*, *LogViewer*, and *PropertiesViewer*.

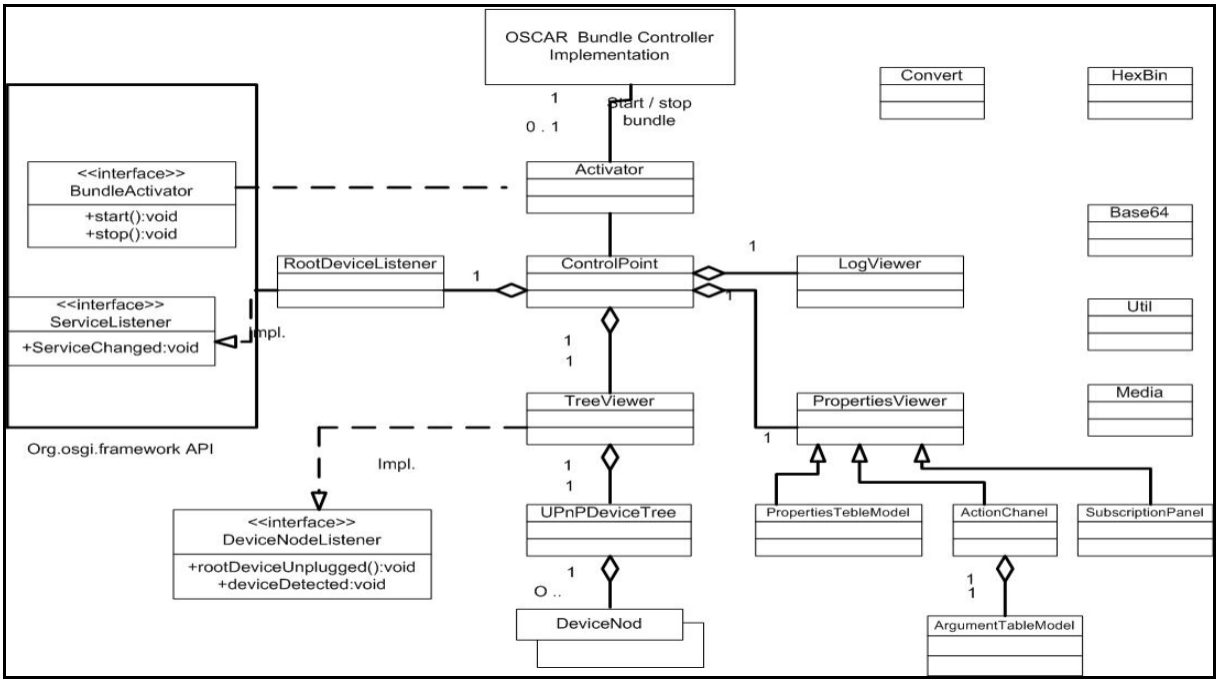

Fig.6 Class Diagram fort he UPnP Control Point

4. Conclusion

Service Discovery is the important aspect and one of the most complicated part of the smart home networks and technology.

The application of UPnP and OSGi is a good option for the smart home networks building, in order to solve the service device and discovery and to integrate the different home networks technologies and its services.

From the model of simulation of service discovery of residential gateway for the smart home is expected that it can be competent for the implementation of service and device discovery, which is one of the important aspects for the home networks development. This work is also still on the development.

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Authors:

Budi Erixson
Prof. Jochen Seitz
Fachgebiet Kommunikationsnetze.
D-98684 Ilmenau
Phone: +49 3677 69 1137 / +49 3677 69 2614
Fax: +49 3677 69 1143
E-mail: {budi.erixson, jochen.seitz}@tu.ilmenau.de